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C E R T I F I C A T I O N

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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1

1 Monitoring unit alongside an assistance system
2 for motor vehicles

3

4 The present invention relates to a monitoring unit for the
5 outside in a motor vehicle's direction of travel, which unit
6 includes at least one camera system having an image-recording
7 sensor.

8

9 The present invention further relates to an assistance system
10 for motor vehicles, in particular for traffic-sign and/or
11 traffic-lane registering, having at least one monitoring unit
12 registering the outside in the motor vehicle's direction of
13 travel, with said monitoring unit including at least one cam-
14 era system having an image-recording sensor.

15

16 Intelligent Advanced Driver Assistance Systems (ADAS) will
17 play an increasingly important role in up-to-date motor vehi-
18 cles of the future. Said vehicles will contain, for example,
19 monitoring units such as camera systems having, for instance,
20 digital CMOS (Complementary Metal-Oxide Semiconductor) or CCD
21 (Charge-Coupled Device) image sensors as aids that register
22 the outside, for example in the motor vehicle's direction of
23 travel.

24

25 Pure black/white (B/W) - that is to say monochrome - image re-
26 cording is for most tasks more favorable than color image re-
27 cording in association with image-processing systems of said
28 type employed in the automobile sector for registering travel
29 environments. However, applications do exist where color in-
30 formation obtained from, for example, the three RGB primary
31 colors red (R), green (G), and blue (B), and/or other colors
32 such as, for instance, yellow (Y) etc. can be important for
33 attaining a higher confidence level for the output vector gen-

1 erated by an image-processing means.

2

3 An instance thereof is traffic-sign recognition, with its be-
4 ing possible to recognize by way of the, where applicable, in-
5 dividual color information (R and/or G and/or B, and/or other
6 colors such as, for instance, Y etc.) whether the sign con-
7 cerned is a prohibition sign or a sign giving orders, or one
8 that purely provides information.

9

10 Another function is recognizing colored lane markings associ-
11 ated with, for example, roadworks. Color information is help-
12 ful here, too, and necessary to be able, for example, to dis-
13 tinguish between the normal white markings that are no longer
14 valid and the additional yellow lane markings.

15

16 Conversely, purely monochrome (B/W) image recording will suf-
17 fice for the purpose of recognizing objects such as obstacles,
18 other vehicles, and cyclists or other persons because color
19 information (R, G, B, Y etc.) will as a rule not provide bet-
20 ter recognition quality.

21

22 The object of the invention is to provide an improved monitor-
23 ing unit for the outside in a motor vehicle's direction of
24 travel, which unit includes at least one camera system having
25 an image-recording sensor, and further to provide an improved
26 assistance system for motor vehicles, in particular for traf-
27 fic-sign and/or traffic-lane registering.

28

29 Said object is achieved by means of the features of the inde-
30 pendent claims.

31

32 Advantageous embodiments and developments that can be used
33 singly or in combination with each other are the subject of

1 the dependent claims.

2

3 The invention builds on generic monitoring units for the out-
4 side in a motor vehicle's direction of travel in that the
5 monitoring unit includes at least one camera system having an
6 image-recording sensor having color coding (R, G, B, Y, ...) in
7 partial areas but otherwise monochrome coding (B/W). The
8 present invention thus proceeds from an image-recording sensor
9 that is substantially embodied as monochrome (B/W) or, as the
10 case may be, coded and inventively has color coding (R and/or
11 G and/or B and/or other colors such as, for instance, Y etc.)
12 in partial areas.

13

14 For the purpose of recognizing or, as the case may be, assign-
15 ing specific colors of traffic signs it is proposed providing
16 a color coding (R and/or G and/or B and/or other colors such
17 as, for instance, Y etc.) of vertical stripes and/or areas on
18 the right-hand and/or left-hand image edge. Because traffic
19 signs move from the center of the image outward from the per-
20 spective of a camera mounted in the front area of a motor ve-
21 hicle traveling in a straight line, the color of the sign and
22 the basic information associated therewith (prohibition, or-
23 ders, other information) can be advantageously determined when
24 the sign is located within the color-coded stripes or, as the
25 case may be, areas.

26

27 For the purpose of recognizing a lane marking's for instance
28 yellow or white color it is proposed providing a color coding
29 (R and/or G and/or B and/or other colors such as, for in-
30 stance, Y etc.) of horizontal stripes and/or areas on the sen-
31 sor's bottom image edge, preferably in the area where the cam-
32 era has a view onto the road directly over the hood, particu-
33 larly in the case of a customary automobile. The camera can,

1 of course, be arranged analogously when the inventive monitor-
2 ing unit is employed in a truck or van etc. As said area is
3 not absolutely essential for image evaluating in terms of ob-
4 ject detecting or lane registering it can advantageously be
5 used for color-recognition purposes. Because traffic lanes can
6 be seen from the center/top of the central image area down to
7 the bottom left-hand or, as the case may be, right-hand image
8 area when the camera is mounted on the front of a vehicle
9 traveling in a straight line, then in addition to the traffic
10 lane's position the color can advantageously be determined and
11 made available to an image-processing system.

12

13 In order to obtain the desired color information (R and/or G
14 and/or B and/or other colors such as, for instance, Y etc.) it
15 is proposed attaching a tiny color filter, where applicable
16 specifically accommodated to the application, in front of each
17 individual cell (pixel) of the stripes or, as the case may be,
18 areas concerned.

19

20 The color-coded stripes and/or areas are in a first embodiment
21 embodied as, for example, a single color (R; Y; etc.).

22

23 The vertical stripes and/or areas expediently have, for exam-
24 ple, a red (R) color coding and the horizontal stripes and/or
25 areas preferably a yellow (Y) color coding.

26

27 The color-coded horizontal and vertical stripes and/or areas
28 can alternatively or additionally be embodied as a combination
29 of two colors (R, G). In particular vertical stripes and/or
30 areas having red (R) and green (G) color coding have proved
31 useful for increasing the contrast of signs that give orders
32 and are placed in front of trees.

33

1 For obtaining the desired color information (R, G, B) it is
2 proposed in a further embodiment to arrange a tiny color fil-
3 ter in one of the three RGB primary colors red (R), green (G),
4 and blue (B) in front of each individual cell (pixel) of the
5 stripes or, as the case may be, areas concerned, with said
6 filters being arranged preferably in what is termed the "Bayer
7 pattern".

8

9 The invention further comprises an assistance system having a
10 monitoring unit of the aforementioned type. The monitoring
11 unit's advantages will in this way also come to bear within
12 the scope of an overall system, in particular for traffic-sign
13 and/or traffic-lane registering. The ratio of monochrome cod-
14 ing (B/W) to partial color coding is therein preferably
15 80:20%. Depending on the focus of the specific application the
16 partially color-coded areas can also occupy 25% or up to 40%
17 of the sensor surface.

18

19 The main advantage of an inventive monitoring unit for the
20 outside in a motor vehicle's direction of travel or, as the
21 case may be, of an assistance system for motor vehicles in-
22 cluding said type of monitoring unit having a partially color-
23 coded (R and/or G and/or B and/or other colors such as, for
24 instance, Y etc.) camera is that all relevant data for regis-
25 tering travel environments can for the first time be obtained
26 using just one camera. Owing to the camera's substantially
27 monochrome (B/W) image recorder there will be no constraints
28 on sensitivity so that reliable evaluating will be ensured
29 even in poor light conditions; the color coding (R and/or G
30 and/or B and/or other colors such as, for instance, Y etc.) in
31 the sensor's edge area will not compromise applications for
32 which the purely monochrome (B/W) image is more favorable.

33

1 By contrast, color coding (R and/or G and/or B and/or other
2 colors such as, for instance, Y etc.) having vertical stripes
3 and/or areas on the right-hand and/or left-hand edge of the
4 sensor's image field will provide reliable information about
5 the color (R, G, B, Y, ...) of traffic signs; the color coding
6 (R, G, B, Y, ...) in the bottom image area will provide reli-
7 able information about the color of lane markings.

8

9 A single camera can thus be used for all relevant applica-
10 tions, and that will advantageously save costs and mounting
11 space.

12

13 The invention is described below with reference to the accom-
14 panying drawing and with the aid of a preferred exemplary em-
15 bodiment.

16

17 Fig. 1 is the exemplary image, shown in monochrome
18 (B/W), of a scene outside a motor vehicle;

19

20 Fig. 2 is a schematic sketch of a possible color-filter
21 distribution (R, G, B) of the image recorder of
22 a monitoring unit's camera;

23

24 Fig. 3 shows an enlarged section of the color-filter
25 distribution according to Fig. 2;

26

27 Fig. 4 is the exemplary image according to Fig. 1 show-
28 ing a scene outside that has been partially
29 color-coded according to Fig. 2; and

30

31 Figs. 5 and 6 are further instances of a color-filter distri-
32 bution of a monitoring unit's image recorder.

33

1 Fig. 1 is the exemplary image, shown in monochrome, of a scene
2 outside a motor vehicle. What is disadvantageous about
3 black/white (B/W) image recording of said type is the lack of
4 color information that could be obtained from, for example,
5 the three primary colors red (R) and/or green (G) and/or blue
6 (B) and/or other colors such as, for instance, Y etc.

7

8 Color information (R, G, B, Y, ...) of said type can be impor-
9 tant for attaining a higher confidence level for the output
10 vector generated by an image-processing means, in particular
11 for recognizing traffic signs, with its being possible to rec-
12 ognize by way of the color information (R and/or G and/or B
13 and/or other colors such as, for instance, Y etc.) whether the
14 sign concerned is a prohibition sign or a sign giving orders -
15 as in the case of the speed-limit sign on the right of the im-
16 age section shown Fig. 1 - or one that purely provides infor-
17 mation (not shown).

18

19 A further function is recognizing colored lane markings asso-
20 ciated with roadworks. It is helpful here and necessary to
21 distinguish between the normal white markings that are no
22 longer valid and the additional yellow lanes.

23

24 Conceivable solutions featuring an exclusively color-coded (R,
25 G, B, Y, ...) image recorder are not only more compute-bound
26 and hence more expensive; they also have the disadvantage that
27 monochrome (B/W) images are more favorable for a number of
28 outside applications, in particular for the purpose of detect-
29 ing objects such as obstacles, other vehicles, and cyclists or
30 other persons and the like, or night-time applications.

31

32 To resolve this conflict of requirements the present invention
33 proposes the use in a generic monitoring unit of a, for exam-

1 ple, specially embodied CCD sensor 10 having color coding (R,
2 G, B, Y, ...) in partial areas 11, 12, 13 but otherwise mono-
3 chrome coding (B/W). The present invention in other words pro-
4 ceeds from a sensor 10 that is embodied as substantially mono-
5 chrome (B/W) or, as the case may be, coded and has color cod-
6 ing (R, G, B, Y, ...) in partial areas. That could be achieved
7 by means of, for instance, a color coding (R, G, B, Y, ...) of
8 vertical stripes (not shown) or areas on the right-hand 11 and
9 left-hand 12 image edge, and would be helpful, for example,
10 for assigning traffic signs the correct color (R, G, B, Y,
11 ...). Because the traffic signs move from the center of the
12 image outward from the perspective of a camera mounted in the
13 front area of a motor vehicle traveling in a straight line,
14 the color (R, G, B, Y, ...) of the sign can be determined when
15 the sign is located within the color-coded (R, G, B, Y, ...)
16 stripes or, as the case may be, areas 11, 12.

17
18 The expedient approach for recognizing the color of the traf-
19 fic lane (yellow or white, for example) is also to provide
20 color coding, in particular yellow (Y) coding, in the bottom
21 area 13 of the sensor 10, preferably in the area where the
22 camera has a view onto the road directly over the hood in the
23 case of a customary automobile. As said area is not absolutely
24 essential for image evaluating in terms of object detecting or
25 lane registering it can be used for color-recognition (Y) pur-
26 poses. Because traffic lanes can be seen from the center/top
27 of the central image area down to the bottom left-hand and
28 right-hand image area when the camera is mounted on the front
29 of a vehicle traveling in a straight line, then in addition to
30 the traffic lane's position the color can be determined and
31 made available to an image-processing system. This feature is
32 not, of course, restricted to motor vehicles having a hood but
33 can be realized analogously when the inventive monitoring unit

1 is employed in particular in a truck or van etc.
2
3 Especially in the case also of night-vision applications the
4 best possible sensitivity is necessary across the entire,
5 which is to say unfiltered, wavelength spectrum, including the
6 near infrared. Since, though, a much smaller angular range
7 generally has to be detected here, it suffices to provide a
8 smaller central area with no color coding.
9
10 Fig. 2 is a schematic sketch of a possible color-filter dis-
11 tribution (R, G, B) of the image recorder 10 of a monitoring
12 unit's camera. The light-sensitive cells of a non color-coded
13 (N) CCD sensor 10 in the monitoring unit's digital camera nor-
14 mally only register brightness values. In order to obtain
15 color information (R, G, B, Y, ...) a tiny color filter is to
16 be attached in front of each individual cell for example in
17 one of the three RGB primary colors red (R), green (G), and/or
18 blue (B), and/or another color such as, for instance, yellow
19 (Y) etc. Filters constructed from primary colors are usually
20 attached in the arrangement R-G-R-G and, in the next cell, G-
21 B-G-B, and in this arrangement produce what is termed the
22 "Bayer pattern".
23
24 Fig. 3 shows an enlarged section of the color-filter distribu-
25 tion (R, G, B) according to Fig. 2 arranged in the Bayer pat-
26 tern. It can clearly be seen how each CCD element only sup-
27 plies the information for a single color component so that the
28 adjacent pixels accordingly have to be used for calculating
29 the actual color. This process is referred to as "color inter-
30 polating".
31
32 Color information useful in the context of road traffic can be
33 obtained within the Bayer-pattern coded stripes or, as the

1 case may be, areas 11, 12, 13 of the sensor 10 by means of
2 color interpolating of said type and made available to an im-
3 age-processing system:

4

5 The corresponding exemplary image according to Fig. 1 showing
6 a scene outside that has been partially color-coded according
7 to Fig. 2 is shown in Fig. 4.

8

9 The color information does not have to consist of the three
10 primary colors: It is also possible only to use single color
11 filters such as, for instance, red (R) for signs giving orders
12 or yellow (Y) for lane markings associated with, for example,
13 roadworks. Combinations of red (R) and green (G) color filters
14 or others specifically accommodated to the application have
15 also proved useful for increasing the contrast of signs that
16 give orders and are placed in front of trees. Color filters of
17 said type can advantageously also be arranged spaced apart,
18 being located, for example, on every other pixel in a row
19 and/or column; that means in any combination with non-coded
20 (N) pixels or pixels coded in another color or, as the case
21 may be, where applicable specifically accommodated color fil-
22 ters.

23

24 Arrangements and further instances of color coding that offer
25 this type of advantage and can be used instead of the "Bayer
26 pattern" are shown in Figs. 5 and 6:

27

28 Fig. 5 shows clearly how only every other pixel in a row
29 and/or every other column has been provided with red color
30 filters (R) for recognizing, for instance, signs giving or-
31 ders.

32

33 Fig. 6 shows the advantageous embodiment of a combination of

1 two colors. Instead of R-G-R-G and in the next row G-B-G-B as
2 in the case of the "Bayer pattern", color filters are used in
3 the pattern R-N-R-N and in the next row N-G-N-G, with N signi-
4 fying no color coding.

5

6 The main advantage of a partially color-coded camera is that
7 all relevant data for registering travel environments can be
8 obtained using just one camera. Owing to the camera's substan-
9 tially monochrome (B/W) image recorder there will be no
10 constraints on sensitivity so that reliable evaluating will be
11 ensured even in poor light conditions; the color coding (R, G,
12 B, Y, ...) in defined edge areas 11, 12, 13 of the sensor 10
13 will not compromise applications for which the purely mono-
14 chrome (B/W) image is more favorable. By contrast, color cod-
15 ing (R, G, B, Y, ...) having vertical stripes on the left-hand
16 11 and right-hand 12 edge of the sensor's image field will
17 provide reliable information about the color (R, G, B, Y, ...) of
18 traffic signs; the color coding (R, G, B, Y, ...) in the
19 bottom image area 13 will provide reliable information about
20 the color of traffic lanes.

21

22 A single camera can thus be used for all applications, and
23 that will advantageously save costs and mounting space.

24

25 The present invention is thus especially suitable for imple-
26 mentation in an assistance system for motor vehicles, in par-
27 ticular for traffic-sign and/or traffic-lane registering. It
28 will advantageously increase road-traffic safety not only in
29 combination with existing assistance systems for motor vehi-
30 cles such as blind-spot detection, LDW (Lane Departure Warn-
31 ing) lane monitoring, night vision etc.